Bovine milk quality related to the minimum requirements demanded by current Brazilian legislation

Qualidade do leite bovino relacionada aos requisitos mínimos exigidos pela legislação brasileira atual

Maurício Fanin
ORCID: https://orcid.org/0000-0001-7696-4998
Universidade Paranaense, UNIPAR, Brazil
E-mail: fanin@hotmail.com

Camila de Cuffa Matusaiki
ORCID: https://orcid.org/0000-0002-2875-108X
Universidade Paranaense, UNIPAR, Brazil
E-mail: camila_cuffa@hotmail.com

Antonio Sergio Ferraudo
ORCID: https://orcid.org/0000-0002-7089-923X
FCAV, Unesp Jaboticabal, Brazil
E-mail: fsajago@gmail.com

Maria Augusta Dorigan Bondezan
ORCID: https://orcid.org/0000-0001-8345-8065
Universidade Paranaense, UNIPAR, Brazil
E-mail: mariadorigan.vet@gmail.com

Luiz Paulo de Oliveira
ORCID: https://orcid.org/0000-0002-1612-9816
Universidade Paranaense, UNIPAR, Brazil
E-mail: luizpauloater@hotmail.com

Dérick de Almeida Marchi
ORCID: https://orcid.org/0000-0003-3504-6466
Universidade Paranaense, UNIPAR, Brazil
E-mail: derick.marchi@edu.unipar.br

Maria Eduarda da Silva Melo
ORCID: https://orcid.org/0009-0003-7273-5006
Universidade Paranaense, UNIPAR, Brazil
E-mail: maria.melo.02@edu.unipar.br

Lisiane de Almeida Martins
ORCID: https://orcid.org/0000-0003-0700-2634
Faculdade de Ensino Superior Santa Bárbara (FAESB). *Campus* Tatuí, SP, Brazil.
E-mail: lisiane.almeida.martins@gmail.com

Ricardo de Melo Germano
ORCID: https://orcid.org/0000-0002-5925-1408
Universidade Paranaense, UNIPAR, Brazil
E-mail: prof.ricardogermano@gmail.com

Luciana Kazue Otutumi
ORCID: https://orcid.org/0000-0003-0426-6431
Universidade Paranaense, UNIPAR, Brazil
E-mail: otutumi@prof.unipar.br

RESUMO

Levando-se em consideração a busca cada vez maior por uma produção de leite com qualidade, objetivou-se avaliar a qualidade do leite de 33 propriedades localizadas na região noroeste do Paraná no ano de 2018, relacionando-as à legislação vigente (instrução normativa 76 de 26 de novembro de 2018).

Os resultados da contagem padrão em placas (CPP), contagem de células somáticas (CCS), gordura, extrato seco desengordurado, sólidos totais, lactose e proteína foram tabulados. Verificou-se desconformidade relacionada à legislação de 53% das amostras para CPP e 21,8% para CCS. Na análise das médias geométricas, 27,3% apresentaram três meses consecutivos acima dos limites aceitáveis para CCS e 63,6% para CPP. A análise de correspondência múltipla dos resultados de desconformidade evidenciou dois processos envolvendo, cada um, três variáveis fortemente associadas: CCS, gordura e sólidos totais e CCS, lactose e sólidos totais. Essas associações vieram de 56,3% da variabilidade contida no conjunto de dados, demonstrando que resultados de alta CCS afetam negativamente os percentuais de gordura e sólidos totais, além da lactose e sólidos totais e que apesar dos avanços tecnológicos, muitos produtores ainda encontram dificuldades em atender a legislação

Palavras-chave: Contagem bacteriana; Gordura; Lactose; Contagem células somáticas; Sólidos totais

ABSTRACT

Taking into account the increasing search for quality milk production, the objective was to evaluate the milk quality of 33 properties located in the northwest region of Paraná in 2018, relating them to current legislation (normative instruction 76). The results of standard plate count (SPC), somatic cell count (SCC), fat, non-fat solids, total solids, lactose and protein were tabulated. There was non-compliance related to the legislation of 53% of the samples for SPC and 21.8% for SCC. In the analysis of geometric means, 27.3% presented three consecutive months above the acceptable limits for SCC and 63.6% for SPC. The multiple correspondence analysis of the nonconformity results showed two processes involving, each, three strongly associated variables: SCC, fat and total solids and SCC, lactose and total solids. These associations came from 56.3% of the variability contained in the data set, demonstrating that high SCC results negatively affect the percentages of fat and total solids, in addition to lactose and total solids and that despite technological advances, many producers still find it difficult to meet the legislation.

Keywords: Bacterial count; Fat; Lactose; Somatic cell count; Total solids.

INTRODUCTION

Milk is a food with high nutritional value and the demand for high quality animal protein is growing. Its composition is approximately 87.3% water and 12.7% total solids, ranging from 3.3 to 3.5% total protein, 3.5 to 3.8% fat, 4.9% lactose, 0.7% minerals and also vitamins (SGARBIERI, 2005). However, milk constituents may vary according to factors such as breed, age, mammary gland health, lactation stage, nutritional management and seasons (HARDIE *et al*., 2014).

It should be noted that numerous factors determine the improvement of the quality of the milk produced, whether it is mechanically or manually milked, with production systems equipped with high technology or in simpler forms of production (SILVA; ANTUNES, 2018).

The greatest negative impact on milk quality occurs in cases of animals positive for mastitis and in milking hygiene, with utensils used in the extraction and storage of raw milk (WERNCKE *et al*., 2016). It is known that at the time of milking numerous contaminations with microorganisms can occur, negatively affecting the quality of the product. In addition to the milking system, many other factors interfere with the level of quality found in the product, such as facilities, health and nutritional management of the animals, storage and refrigeration of the milk (ANGELIS; SOUZA; OLIVEIRA, 2016).

There are many challenges to producing high quality milk. Farms need to focus on the efficiency of the activity and the difficulties are encountered by the most varied forms and production systems found in Brazil, whether due to lack of technical knowledge, difficulties in investing in equipment and technologies, infrastructure, ambience and nutrition for animals (LANGONI, 2013).

With this, the challenges increase to achieve the parameters required by current legislation. If strategic actions are not urgently taken, a large number of producers, mainly small family farms, will be unable to market their product.

According to IBGE data, milk production in Brazil in 2021 had a considerable reduction compared to the previous year. This drop was mainly due to high production costs and a decrease in consumption, causing economic losses to producers. According to data published by the Brazilian Agricultural Research Corporation (CARVALHO, 2022), the South region led production with 9.8 billion liters of milk, reaching such a position for the first time, with emphasis on the State of Paraná which represented 14%

of milk generated in Brazil, followed by Rio Grande do Sul with 13.4% and Santa Catarina with 11.7% (CARVALHO, 2022).

Thus, the objective of this study was to evaluate the quality of milk produced in dairy farms located in the northwest region of Paraná, in the year 2018, verifying compliance with the parameters required by current Brazilian legislation.

MATERIALS AND METHODS

To carry out the present study, data provided by a dairy industry in the northwest region of Paraná were tabulated, referring to milk quality control samples from 33 dairy farms, which were collected monthly during a period of ten months in 2018 (n= 330).

The milk samples were sent to the Laboratory of the Paraná Dairy Herd Analysis Program belonging to the Paranaense Association of Holstein Cattle Breeders (Associação Paranaense de Criadores de Bovinos da Raça Holandesa - APCBRH), in Curitiba-PR. The determination of the chemical composition of the milk was performed by determining the protein (g/100g), fat (g/100g), lactose (g/100g), defatted dry extract (g/100g) and total solids (g/100g), by means of infrared radiation spectrophotometry in the Bentley 2000® equipment, as well as somatic cell count (SCC) x 1000/mL. To determine the standard plate count (SPC) x 1000 CFU/mL, the method described by International Dairy Federation (1991).

The data obtained, after being tabulated, were analyzed in relation to compliance with normative instruction 76 of November 26, 2018, Chapter I - Technical regulation of identity and quality of refrigerated raw milk of the Ministry of Agriculture, Livestock and Supply (BRASIL, 2018), which provides for maximum limits of SCC of 500,000 somatic cells per mL of milk and SPC of 300,000 CFU/mL of milk, identifying the number of non-compliant samples (number and percentage). Geometric means were also calculated every three months for the SCC and SPC parameters, in order to verify compliance with current legislation. Descriptive statistics and Pearson's linear correlation were performed using the Biostat® software 5.0 (Ayres et al., 2007). In addition, the properties were classified in relation to compliance with normative instruction 76 into two categories (yes and no), for all analyzed variables. Additionally, data were analyzed using Multiple Correspondence Analysis (MCA) to detect correspondence structures between the considered categories using the Statistica 7 software (STATSOFT, 2018). MCA uses the basic concept of the Chi-square test to

standardize the frequencies. The interrelation pattern was performed by residuals (difference between what was observed and what was expected) in a standardized and adjusted way, that is, expressed in standard deviation units. The residual value to show dependence between categories must be greater than 1.96 for $\alpha = 5\%$ and greater than 1.60 for $\alpha = 10\%$.

RESULTS AND DISCUSSION

In Table 1 it can be seen that the SPC, followed by the SCC, presented a high coefficient of variation, 158.95 and 105.51% respectively, thus indicating a high variability of these data between herds, in the milk samples analyzed in the present work. For milk constituents, the greatest variation was for fat, followed by protein, total solids, lactose and defatted dry extract (Table 1).

Table 1 - Descriptive statistics of the results of the analysis of the quality of bovine milk from 33 producers in the northwest region of Paraná, in the year 2018 (n=330)

Variable	Average	Standard Deviation	CV%
Fat g/100g	3.34	0.38	11.63%
Protein g/100g	3.23	0.17	5.42%
Lactose g/100g	4.50	0.15	3.35%
Total solids g/100g	12.02	0.46	3.85%
DDE[1] g/100g	8.68	0.24	2.87%
SCC[2](x 1000 cél/mL)	409	431	105.51%
SPC[3](x 1000 UFC/mL)	2028	3224	158.95%

[1]Defatted dry extract; [2] Somatic Cell Count; [3] Standard Plate Count; CV%: Coefficient of variation.

Gonçalves *et al*. (2020), evaluating properties producing bovine milk in the region of Aparecida do Tabuado - MS, they also found variable results in the SCC analyzes (81 x 10^3 cells per mL to 3,466 x 10^3 cells per mL, with an average of 571 x 10^3 cells per mL), corroborating the results of the present study. According to the authors, the high SCC count suggests the presence of mastitis in the herds, however, the physicochemical parameters of raw milk did not change, which demonstrates the maintenance of milk quality. On the other hand, in the present study, the physical-chemical patterns showed variations, mainly in relation to the percentage of fat (Table 1).

According to Rysanek, Babak and Zouharova (2007), the evaluation of the quality of raw milk in expansion tanks must be carried out through at least one monthly sample, since the SCC can estimate the percentage of infected mammary quarters, thus

contributing to the assessment of hygienic conditions of milk production on the property and decision-making for improvements in milk quality results.

Despite not being significant, there was a positive correlation between somatic cell count and fat content (Table 2). The correlation of SCC with all other evaluated parameters was negative, showing significant results in relation to lactose ($r = -0.33$; $p < 0.05$) and the defatted dry extract ($r = -0.22$; $p < 0.05$) (Table 2). Lactose levels decreased ($p < 0.05$) with the increase in SCC (Table 2).

Table 2 - Pearson's linear correlation coefficient (r) between Somatic Cell Count (SCC), constituents and Standard Plate Count (SPC), of bovine milk samples from 33 producers in the northwest region of Paraná in the year 2018 (n=330)

Component	R
Fat	0.05
Protein	-0.01
Lactose	-0.33*
Total solids	-0.07
Defatted dry extract	-0.22*
Standard plate Count	-0.001

* Significant linear correlation coefficient ($p < 0,05$).

Machado, Pereira and Sarríes (2000), Noro *et al.* (2006) and Vargas *et al.* (2014) also found a positive correlation between somatic cell count and fat content. This increase in fat levels can be explained by the presence of infection in the mammary gland, causing a reduction in the volume of milk production and increasing the concentration of this constituent (SILVA *et al.*, 2014).

The results of reducing lactose with an increase in SCC (Table 2) may be the result of disturbances in the mammary gland with lower biosynthesis of the constituent, or by increased permeability of the membrane that separates blood from milk, resulting in loss of lactose into the bloodstream (GONZÁLEZ; NORO, 2011).

Table 3 describes the minimum parameters required by normative instruction 76 of the Ministry of Agriculture, Livestock and Food Supply (BRASIL, 2018), and the results of the analysis of the quality of milk from producers in the northwest region of the state of Paraná in 2018. Of the total samples analyzed, 53% were non-compliant for the SPC and 21.8% were above acceptable levels for the SCC.

Table 3 - Bovine milk samples from 33 producers in the northwest region of Paraná, in the year 2018, in non-compliance with the parameters established by Normative Instruction 76 (n=330)

Variables	Legislation (IN76)	n° Non conforming Samples	Non conformity (%)
Fat g/100g	Min. 3.0	47	14.2%
Protein g/100g	Min. 2.9	2	0.6%
Lactose g/100g	Min. 4.3	22	6.7%
Total solids g/100g	Min. 11.4	28	8.5%
DDE* g/100g	Mín. 8.4	39	11.8%
SCC** (x 1000 cél/mL)	Máx. 500	72	21.8%
SPC** (x 1000 UFC/mL)	Máx. 300	175	53%

*Defatted dry extract **Somatic Cell Count ***Standard Plate Count.

The microbiological standard of milk is evaluated by determining the SPC and as a result of good practices in milking and the correct process of cleaning equipment and utensils, SPC reduction is expected (SCABIN; KOZUSNY-ANDREANI; FRIAS, 2012; FAGUNDES *et al*., 2006). On the other hand, high rates of SCC indicate an inflammatory response, which is mainly caused by the presence of microorganisms in the mammary gland of cows, resulting from mastitis (SHARMA; SINGH; BHADWAL, 2011). Therefore, the measurement of SCC helps in detecting problems in the herd, especially in cases of subclinical mastitis, where high counts are indicative of lower milk quality, which in turn causes great economic losses in the world (SILVA *et al*., 2010).

In a study conducted by Candiotto *et al.* (2020) in small properties in the southern region of Brazil, the authors found that 56.1% and 56.8% of the samples taken from October 2014 to July 2016 did not meet the Brazilian regulations for SCC and SPC, respectively. Esses resultados se aproximam dos resultados encontrados no presente trabalho para a SPC (53%).

In a survey carried out by Müller, Maciel and Rempel (2022), evaluating several properties in Rio Grande do Sul in relation to milk quality, the authors found that 17

properties (53.2%) had SCC with levels above the limit allowed by law, which is 500,000 cells/mL, corroborating the results obtained in the present study.

In a similar way, Schneider *et al.* (2020) evaluating 20 conventional dairy farms and 27 agroecological farms, in three different municipalities in the state of Paraná, whose raw milk samples were collected in two seasons of the year (spring/summer and autumn/winter), the authors also found that 55.6% and 60% of the properties did not meet the requirements for SCC and SPC respectively, referring to the value allowed by normative instruction 76.

For milk constituents, the highest percentages of non-compliance with the minimum requirements for current legislation were 14.2% for fat and 8.5% for total solids (Table 3). On the other hand, Candiotto *et al.* (2020) in bovine milk farms in the southern region, they verified only 4% of non-compliance of the farms in relation to the current legislation for fat, however, close to the results obtained for total solids (9%).

After analyzing the data, it was verified that 27.3% and 63.6% of the milk producers in the study would have the interruption in the collection of the milk produced for presenting three consecutive monthly geometric means above the acceptable limits by the current normative instruction for SCC and SPC, respectively (Table 4).

Table 4 – Number of bovine milk producers in the northwest region of the state of Paraná who presented three or more monthly geometric means of SCC and SPC above the established by normative instruction 76 in the year 2018

| Number of producers with results above	SCC (n, %) (> 500.000 células/mL)	SPC (n, %) (> 300.000 UFC/mL)
None	18 (54.5%)	4 (12.1%)
1	2 (6.1%)	4 (12.1%)
2	4 (12.1%)	4 (12.1%)
3	9 (27.3%)	21 (63.6%)

SCC – Somatic Cell Count; SPC – Standard Plate Count.

In a more recent work by Pereira *et al.* (2022) evaluating small dairy farms of bovine milk in the state of Sergipe, the authors verified that for the results of SPC, the samples showed counts within the values required by law, after adopting sanitary measures with the use of alkaline detergents, acids and sanitizers for cleaning milking equipment. As for SCC, only one of the properties did not reduce the values, due to the producer's difficulty in separating healthy cows from cows with mastitis at the time of milking.

Regarding the Multiple Correspondence Analysis, it was verified the existence of two processes involving three variables each, strongly associated (Figure 1). In one process, SCC, fat and total solids are associated, and in the other SCC, lactose and total solids, for the results of non-compliance with current legislation (BRASIL, 2018), showing that these variables are strongly affected. All these associations came from 56.35% of the variability contained in the dataset.

In a study conducted by Bueno *et al.* (2005), evaluating the relationship between SCC and milk composition, the authors reported that the increase in SCC is related to the reduction of protein, lactose and total solids concentrations, corroborating the results presented in this study (Figure 1). On the other hand, according Najafi *et al.* (2009), Noro *et al.* (2006), Raječevič, Potočnik and Levstek (2003) and Vargas *et al.* (2014), these solids have a strong genetic and nutritional influence on the animals, and the results should be compared, also taking these parameters into account.

Figure 1 - Correspondence map with the categories of results of analysis of quality of bovine milk from producers who attended (S) or did not meet the minimum requirements (N) the parameters fat (gordc), lactose (LACC), somatic cell count (ccsc), total solids (stc) and standard plate count (CPPC).
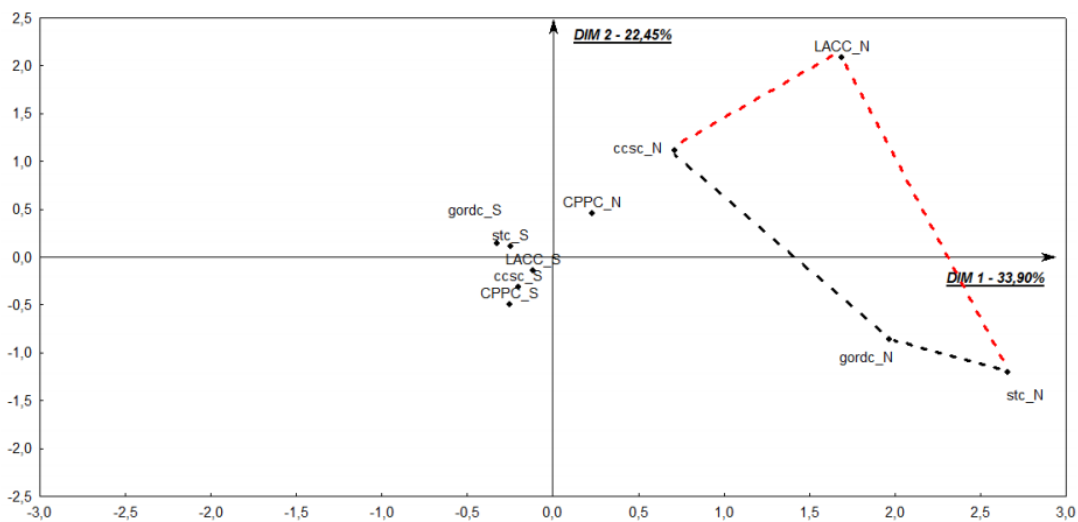
The dotted lines demonstrate the existence of correspondence between three strongly associated variables.

Source: prepared by the author.

The results found in the present work are worrying, since most of the time, they are small properties belonging to family agriculture, which depend on this income for the

maintenance of the rural property. Thus, strategies need to be adopted focused on the efficient management of data obtained from dairy farms, with specialized technical monitoring, in order to improve the evaluation results of milk quality.

CONCLUSIONS

It is concluded that many properties producing bovine milk in the northwest region of the state of Paraná showed unacceptable levels for SPC and SCC under current legislation. With this study it was possible to show that the high SCC interferes in the percentages of fat, total solids and lactose in the samples that did not meet the minimum requirements. Difficulties with the health of the mammary gland, hygiene in the process of obtaining and storing milk still occur frequently in many dairy farms, being extremely important programs for monitoring and effective control of SCC and bacterial Fcount, in addition to prophylactic strategies and measures of good manufacturing practices.

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